CHAPTER 20

PRIMARY ELECTRICAL DISTRIBUTION

20-1. Minimum maintenance activities for primary electrical distribution systems

For the purpose of this manual the primary electrical distribution system comprises all components operating above 600 volts. The tables located at the end of this chapter indicate items that must be performed to maintain systems and equipment at a minimum level of operational readiness. The listed minimum action items should be supplemented by manufacturer-recommended maintenance activities and procedures for specific pieces of equipment. Maintenance actions included in this chapter are for various modes of operation, subsystems, or components. Table 20-1 provides maintenance information for typical primary distribution systems. Table 20-2 provides maintenance information for overhead pole line distribution systems. Table 20-3 provides maintenance information for medium voltage switchgear. Table 20-4 provides maintenance information for primary distribution feeders. Table 20-5 provides maintenance information for transformers. Table 20-6 provides maintenance information for primary distribution system protection.

20-2. Maintenance schedule

Maintenance will take place ordinarily during scheduled shutdowns. However, other conditions that force the issue or provide an opportunity are emergency shutdowns, acts of nature, fault occurrences, associated shutdowns, and abnormal operating conditions. Typical maintenance tasks should be performed on all electrical equipment as applicable. Inspection frequencies may be increased as required based on observations and experience.

a. Typical maintenance tasks. This section presents general instructions for maintaining primary electrical distribution systems.

(1) Personnel should review past maintenance records to find repair patterns. These records may point to certain components that should be closely inspected during performance of preventive maintenance.

(2) Review operator records concerning electrical load readings, and compare with equipment ratings. Operator records regarding operating temperatures and any documented abnormal circumstances associated with the system should also be reviewed.

(3) Primary electrical distribution equipment should be thoroughly inspected and all discrepancies reported to the shift supervisor.

(a) Inspect to ensure that warning signs exist. Replace as required.

(b) Inspect enclosures for damage, unauthorized openings, and corrosion of metallic objects. Repair and paint as required.

(c) Inspect air passages and remove any blockage.

(d) Inspect, investigate, and solve conditions for unusual odors.

(e) Inspect locking devices. Repair as required.

(f) As equipment is operated and tested, listen, investigate, and solve conditions for unusual noises.

(g) Inspect electrical connections for degradation and tightness. Repair as required.

(h) Inspect electrical insulation for discoloration and degradation. Repair as required.

(i) Inspect, investigate, and solve conditions causing carbon tracks.

(j) Inspect equipment grounding components such as conductors and connections. Repair as required.

(k) Inspect insulators for damage. Replace as required.

(l) Inspect liquid immersed equipment for leaks and damage.

(m) Inspect indicating lights for correct illumination.

(4) Remove debris, dirt, and other foreign objects from all components, housings, cabinets, panels, etc.

(5) All electrical connections should be torqued to the proper design value.

(6) Verify operation of space heaters and control thermostat. Check thermostat set point for proper setting.

(7) Verify the grounding of the equipment and associated neutral where applicable.

(8) Conduct an infrared test on all main current carrying equipment for hot spots that may indicate overload conditions or loose connections.

(9) Using calibrated test instruments, calibrate ammeters, voltmeters, etc. Verify continuity of metering selector switch contacts with ohmmeter.

b. Overhead pole line distribution. Proper maintenance of the overhead pole line distribution system is essential to ensure the reliable delivery of electrical power to facility loads.

(1) Inspect overhead pole line distribution hardware for the following conditions.

(a) Inspect conductors for damage, proper connections, sag, and clearances.

(b) Inspect for leaning and damaged poles.

(c) Inspect earth conditions for washouts, etc., which may affect the foundation integrity of the supporting structure.

(d) Inspect cross arms for deterioration.

(e) Inspect structure anchoring guys.

(f) Inspect overhead pole line mounting hardware, including conductor support and support structure, for looseness.

(g) Inspect transformers, insulators, cutouts, and lightning arresters for damage and cleanliness.

(h) Inspect lightning arrester air gap if applicable.

(i) Inspect right-of-way for clearances to energized equipment from trees, brush, and other grounded objects.

(j) Inspect overhead ground wires and static lines for damage, ground connections, sag, and clearances.

(2) In most cases, cleaning of insulators is not necessary. But, in areas where contaminants such as salt, cement/lime, dust, bird defecation, chemicals, smog, cooling tower effluent, etc., may cause tracking on the insulator surface, cleaning cycles should be established, as the need to clean will vary depending on the severity of contamination.

(3) Test wood poles twenty years after installation and every five years thereafter. Excavate earth around the pole to a depth of 18 inches. Perform non-destructive evaluation of pole strength using sound waves. Prod the pole below ground line to determine the extent of external decay. Perform pole borings below ground line for internal defects. As an alternative to pole boring, an electrical resistance analysis using a shigometer® may be performed. The shigometer® generates a pulsed direct current (DC) electrical current and measures resistance of wood tissues which indicates the condition of the wood.

(4) Conduct radio interference test by monitoring radio frequency test equipment to search for loose connections, flashover, etc.

c. Medium voltage switchgear. A medium voltage switchgear assembly is comprised of switching, interrupting, control, metering, and protective devices housed in a metal enclosure together with associated conductors and electrical interconnections.

(1) Review operator records indicating the number of, and causes for, circuit breaker operation.

(2) Inspect medium voltage switchgear for the following conditions.

(a) Inspect, investigate, and solve conditions causing carbon tracks.

(b) Inspect barriers and shutters for physical damage. Prove shutter operation if possible.

(3) Test switchgear phase bus insulation as described below.

(a) Perform insulation resistance test on each phase-to-phase and phase-to-ground using a megohmmeter.

(b) Perform dielectric absorption test on each phase using a megohmmeter.

(c) Perform DC over-potential test on each phase-to-phase and each phase-to-ground.

(d) Perform power factor test on each phase.

(4) Frequency of circuit breaker inspection should be based on the number of operations and the electrical load interrupted during those operations. The higher the number of operations under load, the more often the circuit breaker should be inspected.

(a) Inspect draw-out contacts for abnormal wear, tension, and discoloration. Correct as required.

(b) Inspect breaker current carrying components for discoloration that may indicate overheating. Replace as required.

(c) Inspect, operate, adjust, and lubricate mechanical linkages. Replace components as required.

(d) Verify the opening and closing sequence of arcing, intermediate, and main contacts on air circuit breakers.

(e) Verify interlocks preventing a closed breaker from being withdrawn from or connected to the switchgear bus.

(f) Inspect and dress current carrying contacts on air circuit breakers in accordance with manufacturer's recommendations.

(g) Inspect the contact wear indicator on vacuum circuit breakers. Replace contact vacuum bottle as required.

(5) Circuit breakers shall be tested in accordance with the following.

(a) Perform test operations to prove correct actuation of breakers' trip and close components, including spring charging motors, trip solenoids, indicating targets, etc.

(b) Perform contact resistance test.

(c) Perform insulation resistance test on each phase-to-phase and phase-to-ground using a megohmmeter.

(d) Perform DC over-potential test on each phase-to-phase and each phase-to-ground.

(e) Perform voltage test across each open contact of vacuum circuit breaker to verify vacuum condition of the vacuum bottle.

(f) Prove circuit breaker operation by actuation of each associated protective relay.

(g) Prove circuit breaker operation by actuation of each breaker manual control switch.

(6) Switchgear provided with alarms should have the alarms actuated by simulating the alarm condition if possible. If operation is not correct, repair and adjust as required.

(7) Test air switches as described below.

(a) Perform DC over-potential test on each pole-to-pole and each pole-to-ground.

(b) Perform contact resistance test across each switch and fuse holder.

d. Primary distribution feeders. Preventive maintenance of electrical cable and busway installations is critical to ensuring continuity of service to loads.

(1) Electrical cables shall be inspected for the following conditions.

(a) Accessible portions of cables, especially splices and terminations, should be visually inspected for insulation damage, tracking, discoloration, signs of corona, etc.

(b) Inspect cable shield grounding equipment such as conductors and connections. Repair as required.

(2) Cable insulation tests shall be performed as described below. Cable test should be done three years after installation and every five years thereafter.

(a) Test the cable shield continuity to ground with ohmmeter.

(b) Perform insulation resistance test with megohmmeter.

(c) Perform DC over-potential test on each cable in accordance with American National Standards Institute/Institute of Electrical and Electronic Engineers (ANSI/IEEE) 400, Guide for Making High-Direct-Voltage Tests on Power Cable Systems in the Field.

(3) Busway insulation tests shall be performed as described below.

(a) Perform insulation resistance test, phase-to-phase and phase-to-ground.

(b) Perform DC over-potential test on each phase.

e. Transformers. Transformers may be either liquid filled or dry type. Each requires different maintenance techniques.

(1) Inspect solid electrical insulation for discoloration and degradation. Repair as required.

(2) For liquid filled transformers, insulating oil shall be tested as described below.

(a) Perform dielectric strength test in accordance with American Society for Testing and Materials (ASTM) D 877, Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids using Disk Electrodes (1995).

(b) Perform acidity test in accordance with ASTM D 1534, Standard Test Method for Approximate Acidity in Electrical Insulating Liquids by Color-Indicator Titration (1995).

(c) Perform color test in accordance with ASTM D 1524, Standard Test Method for Visual Examination of Used Electrical Insulating Oils of Petroleum Origin in the Field (1999).

(d) Should the above oil tests be close to established limits, then laboratory tests for pour point, flash point, viscosity, specific gravity, interfacial tension, free ions, power factor, water content, sulfur compound test, and others listed in ASTM D 117, Standard Guide for Sampling, Test Methods, Specifications, and Guide for Electrical Insulating Oils of Petroleum Origin (1996), may be performed to make a final determination of oil condition.

(3) Transformers utilizing forced cooling systems (fans, oil pumps, etc.) shall be tested as described below.

(a) Inspect forced cooling system equipment for damage, etc.

(b) Operate system by simulating high temperature at controlling devices.

(4) Actuate transformer protective relays such as rate-of-pressure increase relay. If operation is not correct, repair and adjust as required.

(5) Transformers with alarms like temperature, level, pressure, pressure relief device, etc., should have alarms actuated. If operation is not correct, repair and adjust as required.

f. Primary distribution protection. Proper maintenance and application of fuses, relays, and other protective devices ensures electrical equipment is adequately protected and allows selective de-energization of the power distribution system to maximize reliability.

(1) Inspect fuses as described below.

(a) Inspect fuse and fuse holder for physical damage. Replace as required.

(b) Inspect the sealing disk on expulsion type fuses. If defective, replace fuse.

(2) Inspect protective relays as described below.

(a) Inspect relays for signs of physical damage.

(b) Clean the relay of debris and dust.

(c) On disk relays, ensure the rotating disk has proper clearance.

(d) Inspect, investigate, and solve conditions causing the presence of moisture.

(e) On rotating disk relays, rotate the disk and verify proper contact closure. Adjust as required.

(f) Inspect condition of contacts. Replace as required.

(3) Using a calibrated test set, all protective relays should be calibrated.

(4) Inspect lightning arrester air gap if applicable. In most cases, cleaning of arresters installed outdoors is not necessary. But, in areas where contaminants such as salt, cement/lime, dust, bird defecation, chemicals, smog, cooling tower effluent, etc., may cause tracking on the insulator surface, cleaning cycles should be established as the need to clean will vary depending on the severity of contamination.

Table 20-1. Typical primary distribution maintenance

Typical Primary Distribution Maintenance	
Action	***Frequency***
WARNING! MAINTENANCE PERSONNEL SHALL LOCKOUT/TAG EQUIPMENT TO ENSURE DE-ENERGIZATION DURING MAINTENANCE PROCEDURES.	
Review maintenance records.	2 wks
Review operator records.	2 wks
Inspect equipment for the following:	
Inspect to ensure that warning signs exist. Replace as required.	yr
Inspect enclosures for damage, unauthorized openings, and corrosion of metallic objects. Repair and paint as required.	yr
Inspect air passages and remove any blockage.	yr
Inspect, investigate, and solve conditions for unusual odors.	yr
Inspect locking devices. Repair as required.	yr
As equipment is operated and tested, listen, investigate, and solve conditions for unusual noises.	yr
Inspect electrical connections for degradation and tightness. Repair as required.	yr
Inspect electrical insulation for discoloration and degradation. Repair as required.	yr
Inspect, investigate, and solve conditions causing carbon tracks.	yr
Inspect equipment grounding components such as conductors and connections. Repair as required.	yr
Inspect insulators for damage. Replace as required.	yr
Inspect liquid immersed equipment for leaks and damage.	yr
Inspect indicating lights for correct illumination.	yr
Clean equipment.	yr
Tighten electrical connections.	yr
Verify space heater operation.	yr
Verify equipment grounding.	yr
Perform infrared test.	yr
Calibrate recording and indicating metering.	yr

Table 20-2. Overhead pole line distribution

Overhead Pole Line Distribution	
Action	***Frequency***
WARNING! MAINTENANCE PERSONNEL SHALL LOCKOUT/TAG EQUIPMENT TO ENSURE DE-ENERGIZATION DURING MAINTENANCE PROCEDURES.	
Inspect overhead pole line distribution system for the following:	
Inspect conductors for damage, proper connections, sag, and clearances.	6 mos
Inspect for leaning and damaged poles.	6 mos
Inspect earth conditions for washouts, etc., which may affect the foundation integrity of the supporting structure.	6 mos
Inspect cross arms for deterioration.	6 mos
Inspect structure anchoring guys.	6 mos
Inspect overhead pole line mounting hardware, including conductor support and support structure, for looseness.	6 mos
Inspect transformers, insulators, cutouts, and lightning arresters for damage and cleanliness.	6 mos
Inspect lightning arrester air gap if applicable.	6 mos
Inspect right-of-way for clearances to energized equipment from trees, brush, and other grounded objects.	6 mos
Inspect overhead ground wires and static lines for damage, ground connections, sag, and clearances.	6 mos
Clean insulators.	6 mos
Test wood poles (20 years after installation, then every 5 years).	20 yrs/5 yrs
Perform radio interference test.	6 mos

Table 20-3. Switchgear

Switchgear	
Action	***Frequency***
WARNING! MAINTENANCE PERSONNEL SHALL LOCKOUT/TAG EQUIPMENT TO ENSURE DE-ENERGIZATION DURING MAINTENANCE PROCEDURES. SWITCHGEAR BUS INSULATION IS NOT DESIGNED TO PROTECT AGAINST ELECTRICAL SHOCK. CONTACT WITH THIS BUS OR ITS CONNECTIONS SHOULD BE AVOIDED WHEN SWITCHGEAR IS ENERGIZED.	
Review operator records.	yr
Inspect switchgear for the following:	
Inspect, investigate, and solve conditions causing carbon tracks.	yr
Inspect barriers and shutters for physical damage. Prove shutter operation if possible.	yr
Test switchgear phase bus insulation.	
Perform insulation resistance test on each phase-to-phase and phase-to-ground using a megohmmeter.	yr
Perform dielectric absorption test on each phase using a megohmmeter.	yr
Perform DC over-potential test on each phase-to-phase and each phase-to-ground.	yr
Perform power factor test on each phase.	yr
Service circuit breakers.	
Inspect draw-out contacts for abnormal wear, tension, and discoloration. Correct as required.	yr
Inspect breaker current carrying components for discoloration that may indicate overheating. Replace as required.	yr
Inspect, operate, adjust, and lubricate mechanical linkages. Replace components as required.	yr
Verify the opening and closing sequence of arcing, intermediate, and main contacts on air circuit breakers.	yr
Verify interlocks preventing a closed breaker from being withdrawn from or connected to the switchgear bus.	yr
Inspect and dress current carrying contacts on air circuit breakers in accordance with manufacturer’s recommendations.	yr
Inspect the contact wear indicator on vacuum circuit breakers. Replace contact vacuum bottle as required.	yr
Test circuit breakers.	

Table 20-3. Switchgear (continued)

Switchgear	
Action	***Frequency***
Perform test operations to prove correct actuation of breakers' trip and close components, including spring charging motors, trip solenoids, indicating targets, etc.	yr
Perform contact resistance test.	yr
Perform insulation resistance test on each phase-to-phase and phase-to-ground using a megohmmeter.	yr
Perform DC over-potential test on each phase-to-phase and each phase-to-ground.	yr
Perform voltage test across each open contact of vacuum circuit breaker to verify vacuum condition of the vacuum bottle.	yr
Prove circuit breaker operation by actuation of each associated protective relay.	yr
Prove circuit breaker operation by actuation of each breaker manual control switch.	yr
Verify switchgear alarms.	yr
Test air switch.	
Perform DC over-potential test on each pole-to-pole and each pole-to-ground.	yr
Perform contact resistance test across each switch and fuse holder.	yr

Table 20-4. Primary distribution feeders

Primary Distribution Feeders	
Action	***Frequency***
WARNING! MAINTENANCE PERSONNEL SHALL LOCKOUT/TAG EQUIPMENT TO ENSURE DE-ENERGIZATION DURING MAINTENANCE PROCEDURES. HIGH VOLTAGE TESTING OF CABLE MAY CAUSE INSULATION FAILURE. ALTERNATE POWER SOURCE TO SERVE THE LOAD SHOULD BE PLANNED FOR PRIOR TO TESTING.	
Inspect cable installations for the following:	
Accessible portions of cables, especially splices and terminations, should be visually inspected for insulation damage, tracking, discoloration, signs of corona, etc.	yr
Inspect cable shield grounding equipment such as conductors and connections. Repair as required.	yr
Cable insulation test[1].	
Test the cable shield continuity to ground with ohmmeter.	3 yrs/5 yrs
Perform insulation resistance test with megohmmeter.	3 yrs/5 yrs
Perform DC over-potential test on each cable in accordance with ANSI/IEEE 400.	3 yrs/5 yrs
Busway insulation test	
Perform insulation resistance test, phase-to-phase and phase-to-ground.	5 yrs
Perform DC over-potential test on each phase.	5 yrs

[1]Three years after installation, then every five years.

Table 20-5. Transformers

Transformers	
Action	***Frequency***
WARNING! MAINTENANCE PERSONNEL SHALL LOCKOUT/TAG EQUIPMENT TO ENSURE DE-ENERGIZATION DURING MAINTENANCE PROCEDURES.	
Inspect solid electrical insulation for discoloration and degradation.	yr
Perform insulating oil test for liquid filled transformers	
Perform dielectric strength test in accordance with ASTM D 877.	yr
Perform acidity test in accordance with ASTM D 1534.	yr
Perform color test in accordance with ASTM D 1524.	yr
Verify forced cooling systems	
Inspect forced cooling system equipment for damage, etc.	yr
Operate system by simulating high temperature at controlling devices.	yr
Verify transformer relay protection	yr
Verify transformer alarms	yr

Table 20-6. Primary distribution protection

Primary Distribution Protection	
Action	***Frequency***
WARNING! MAINTENANCE PERSONNEL SHALL LOCKOUT/TAG EQUIPMENT TO ENSURE DE-ENERGIZATION DURING MAINTENANCE PROCEDURES.	
Inspect fuses for the following:	
Inspect fuse and fuse holder for physical damage. Replace as required	yr
Inspect the sealing disk on expulsion type fuses. If defective, replace fuse.	yr
Inspect protective relays for the following:	
Inspect relays for signs of physical damage.	yr
Clean the relay of debris and dust.	yr
On disk relays, ensure the rotating disk has proper clearance.	yr
Inspect, investigate, and solve conditions causing the presence of moisture.	yr
On rotating disk relays, rotate the disk and verify proper contact closure. Adjust as required.	yr
Inspect condition of contacts. Replace as required.	yr
Calibrate protective relays.	yr
Inspect lightning arrester air gap (if applicable).	yr
Clean arresters as required. Cleaning cycle will depend on environment in which arrester is installed.	as req'd